Water Quality Sampling Of Grand Valley Creek In 2003

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EXECUTIVE SUMMARY

A partnership of agricultural, residential, and recreational landowners concerned about water quality and low flow in Grand Valley Creek was formed in 2002. Alberta Environment provided a water quality sampling and flow gauging program in this watershed in 2003, to document current conditions in this basin and assist planning by this partnership. This sampling program focused on key water quality variables in Grand Valley Creek that may be indicative of impacts from ranching or wastewater from septic fields.

The concentration of total phosphorus in Grand Valley Creek usually exceeded the Alberta Surface Water Quality Guideline of 0.05 mg/L at sites downstream from Range Road 53, the approximate boundary between forested land and foothills grasslands. Total dissolved phosphorus was similarly elevated in this reach. TN was relatively low at headwater sites, except for individual values that exceeded the Alberta Surface Water Quality Guideline, but more frequently exceeded this guideline downstream from the Simpson Reservoir and near the mouth of Grand Valley Creek. Total kjeldahl nitrogen concentrations, an indicator of organic nitrogen from wastewater, rose considerably downstream of Range Road 53 and peaked downstream from the Simpson Reservoir. Both fecal coliforms and *E. coli* increased downstream from Range Road 53. Both variables were frequently over the irrigation and recreation guidelines at sites between the Wildcat Hills Road and the mouth of the creek, except for the site immediately downstream from Simpson Reservoir. Median TSS concentrations were relatively low from the Croatian Retirement Camp to Range Road 53 (sites 2 to 5) in 2003, but increased appreciably downstream from Range Road 53.

This sampling program provided no evidence of adverse water quality impacts on Grand Valley Creek from either the Croatian Retirement Camp or residential properties at Hacienda Estates. Coliform counts, TP, and TDP concentrations in Grand Valley Creek increased above the available water quality guidelines downstream of Range Road 53. This suggests that ranching activities downstream from Range Road 53 may be affecting water quality in Grand Valley Creek.

Another year of sampling during a period with higher precipitation would better define the natural range of variation in water quality and flow in Grand Valley Creek.

ACKNOWLEDGEMENTS

I thank all technical and professional staff of Alberta Environment (AENV) who assisted in the sampling program and report preparation, and Tim Dietzler, Municipal District of Rockyview for help in site selection. Bridgette Halbig of the Environmental Monitoring and Evaluation Branch (AENV) assisted in data compilation and graphics. I also thank Hamish Kerfoot who provided regular and reliable staff gauge measurements. Tim Dietzler and Ron Zurawell (AENV) provided review comments on the draft report.

TABLE OF CONTENTS

EXECUTIVE SUMMARY iii
ACKNOWLEDGEMENTS iv
TABLE OF FIGURES vi

1.0 INTRODUCTION 1

2.0 METHODS 1
2.1 SAMPLING SITES AND ANALYSIS 1

3.0 RESULTS AND DISCUSSION 2
3.1 FLOW 2
3.2 PHOSPHORUS 2
3.3 NITROGEN 3
3.4 COLIFORMS 4
3.5 TOTAL SUSPENDED SOLIDS 5
3.6 DISSOLVED OXYGEN 6
3.7 WATER TEMPERATURE 6
3.8 pH 6
3.9 CONDUCTIVITY 7

4.0 CONCLUSIONS 7

5.0 RECOMMENDATIONS 7

6.0 LITERATURE CITED 8

LIST OF FIGURES

Figure 1. Sampling locations on Grand Valley Creek in 2003 9

Figure 2. Discharge in Grand Valley Creek near Cochrane (05BE905), April 14-July 18, 2003 10

Figure 3. Total phosphorus at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 11

Figure 4. Total dissolved phosphorus at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 12

Figure 5. Total nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 13

Figure 6. Nitrite+nitrate nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 14

Figure 7. Total kjeldahl nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 15

Figure 8. Total ammonia nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 16

Figure 9. Fecal coliform counts at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 17

Figure 10. Escherichia coli counts at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 18

Figure 11. Non-filterable residue at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 19

Figure 12. Dissolved oxygen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 20

Figure 13. Water temperature at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 21

Figure 14. Air temperature at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 22

Figure 15. pH at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 23

Figure 16. Specific conductance at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003 24

1.0 INTRODUCTION

A partnership of agricultural, residential, and recreational landowners concerned about water quality and low flow in Grand Valley Creek was formed in 2002. Basin residents are concerned that current activities in the basin may adversely affect water quality, and this creek is reported to stop flowing in extremely dry years.

Grand Valley Creek enters the Bow River just west of Cochrane, Alberta. The lower reaches of the Grand Valley Creek basin (sites 6 to 10 in Figure 1) are used for livestock and mixed farming, while the reaches upstream from site 4 (at Range Road 53) are largely in forested areas used for recreational properties at the Croatian Retirement Camp and one commercial riding business, Griffin Valley Ranch. Site 4 represents the approximate boundary between grazing operations and other land uses. There has also been some logging and peat mining within the basin upstream from Site 2. Site 5 drains a tributary of Grand Valley Creek with residential properties in a development called Hacienda Estates.

Flows were previously gauged and water quality was sampled in Grand Valley Creek at Highway 1a during peak flows from April 3 to May 15, 1997. However, no basin-wide water quality sampling has been done along Grand Valley Creek.

Alberta Environment (AENV) provided a water quality sampling and flow gauging program in this watershed in 2003, designed to document current conditions in this basin and assist planning by the partnership. This sampling program focused on key water quality variables in Grand Valley Creek such as nutrients, coliforms, and suspended solids, which may be indicative of impacts from ranching or wastewater from septic fields. This program did not include sites on the Bow River, and accordingly was not designed to assess impacts on the Bow River. This report presents and interprets results from sampling in 2003.

2.0 METHODS

2.1 SAMPLING SITES AND ANALYSIS

AENV collected grab samples for water chemistry and coliform counts at the sites listed in Figure 1 between April 14 and July 18, 2003. Figure 1 contains GPS coordinates for the various sites. Most sampling sites were selected by the Grand Valley Watershed Group to assess the impacts of different land uses in the basin on water quality. Site 4 was moved upstream to the first available all weather road access, from the location originally proposed by the partnership.

Samples were collected every other week during the high flow period in April and May, and otherwise monthly until July 18 when flows were negligible at most sites (Figure 2)($n = 7$). Hydrolab Surveyor 4 meters were used to measure dissolved oxygen, pH, conductivity and temperature at each site on all sampling days.

A staff gauge was installed in Grand Valley Creek at Highway 1a and read frequently by a volunteer. These readings, and flow measurements by AENV on water quality sampling days,

were used to establish a stage discharge relationship and estimate flows throughout the sampling season.

Maxxam Analytics Inc. provided chemical analyses, and the Provincial Health Laboratory for Southern Alberta provided coliform and *E. coli* counts.

To permit numerical analysis, values less than detection limits were replaced by values one-half the detection limit. Data were then compared to the Alberta Surface Water Quality Guidelines (ASWQG) and the current Canadian Water Quality Guidelines (CCME) (AENV 1999, CCME 2003). Differences in the median concentration of all variables between all sites were tested using a Kruskal-Wallis one-way analysis of variance ($\alpha = 0.05$), followed by an Experimentwise Kruskal-Wallis Multiple Comparison Test using the computer program WQHYDRO (Aroner, 2000).

3.0 RESULTS AND DISCUSSION

3.1 FLOW

The highest flow measured in Grand Valley Creek at Highway 1a was 0.260 m^3/s on April 14, 2003 (Figure 2). It appears that higher flows may have occurred before gauging began on April 14, as flows declined thereafter. However, the peak flow measured in 2003 was similar to the highest flow measured in 1997, when flows peaked at 0.308 m^3/s on April 18 and dropped to 0.061 m^3/s by May 15, 1997. In 2003, flows declined to a negligible 0.001 m^3/s on July 18, with a brief increase in flow around May 12. This increase in flow could have resulted from rain on May 12, and over the previous week.

3.2 PHOSPHORUS

Phosphorus and nitrogen are essential plant nutrients. Excessive phosphorus can cause an increase in the growth of aquatic plants and algae, which can result in low levels of dissolved oxygen through plant respiration at night, impede water flow, and affect aesthetics. Total phosphorus (TP) includes both particulate and dissolved forms of this nutrient. Total dissolved phosphorus (TDP), which excludes particulate forms, is highly reactive, and quickly absorbed by aquatic plants and algae or adsorbed to suspended sediments and other surfaces in a creek. Consequently, TDP is a better measure of phosphorus available for plant and algal growth than total phosphorus (Bradford and Peters 1987).

The median concentration of TP in Grand Valley Creek usually exceeded the ASWQG Guideline of 0.05 mg/L at sites downstream from Range Road 53, the approximate boundary between grazing operations and other land uses in this basin (Figure 3). TP concentrations over this water quality guideline are sufficient in the Bow River to cause nuisance growth of attached algae, or periphyton (Sosiak 2002). However, periphyton biomass (usually measured as chlorophyll *a*) was not measured along Grand Valley Creek in 2003.

Similarly, TDP was greatly elevated from the Anchor X Road to the site below the Simpson Reservoir (Figure 4), with maximum values up to 0.049 mg/L. Concentrations at the Wildcat

Hills Road were significantly higher than at sites from upstream of the Croatian Camp to Range Road 53, and the tributary near Hacienda Estates. Concentrations below the Simpson Reservoir were significantly higher than at each site in this reach except at Range Road 53. These results suggest that most TDP entered Grand Valley Creek between Range Road 53 and the Simpson Reservoir. Concentrations of TP and TDP were not significantly different upstream and downstream from the Croatian Retirement Camp. Furthermore, concentrations were significantly lower in the tributary near Hacienda Estates than in Grand Valley Creek. Accordingly, these results provide no evidence that either the Croatian Retirement Camp or Hacienda Estates had any appreciable impact on phosphorus levels during this sampling program.

3.3 NITROGEN

Nitrogen is another essential nutrient for aquatic plants. Excessive nitrogen can also lead to increased growth of aquatic plants, and the same concerns associated with phosphorus. In addition, high levels of nitrate can impair drinking water quality, and ammonia and nitrite may be toxic to aquatic life. Total nitrogen (TN) analysis accounts for all forms of nitrogen. Nitrite is typically low in surface waters, except below discharge points for wastewater treatment plants. Nitrite and nitrate are often measured together. Total kjeldahl nitrogen (TKN) is a measure of ammonia and organic nitrogen. Nitrite, ammonia, and TKN are often high in wastewater.

TN was relatively low at headwater sites, except for individual values that exceeded the Alberta Surface Water Quality Guideline (Figure 5). TN more frequently exceeded this guideline downstream from the Simpson Reservoir and near the mouth of Grand Valley Creek. However, TN concentrations at the various sites were not statistically different ($P > 0.05$). This increase in TN in the lower basin probably reflects the spatial pattern in TKN concentration, which formed a large part of the TN present in Grand Valley Creek. TKN patterns will be discussed below.

Nitrite+nitrate declined along Grand Valley Creek from the headwaters to the mouth, including the ranching areas downstream from Range Road 53 (Figure 6). Median nitrite+nitrate was significantly higher in the tributary that drained the Hacienda Estates area (Site 5) than in all the Grand Valley Creek sites except near the Griffin Valley Ranch. However, this source had negligible impact on Grand Valley Creek, as median concentrations declined in Grand Valley Creek downstream from this tributary. Since other water quality indicators such as phosphorus concentrations and coliform counts were low in this tributary, it seems unlikely that the elevated nitrite+nitrate there could reflect septic leachate or other human sources. Median nitrite+nitrate was slightly higher in Grand Valley Creek downstream from the Croatian Retirement Camp than upstream, but this small difference in concentration between sites was not statistically significant, and may reflect natural variation. Reasons for the higher nitrite+nitrate concentrations in the headwaters are not known. Higher nitrite+nitrate concentrations were also found in headwater sites, upstream from obvious human sources, in the Elbow River basin (Beers and Sosiak 1993).

TKN concentrations rose considerably downstream of Range Road 53 in ranching areas, and peaked downstream from the Simpson Reservoir (Figure 7). The concentration of TKN was significantly higher at the sites at the Wildcat Hills Road and downstream from the Simpson Reservoir than at all sites upstream from Range Road 53. TKN was elevated in streams receiving

runoff from livestock wintering areas in the Haynes Creek study (Anderson et al. 1998). Accordingly, the increase in TKN in lower Grand Valley Creek could reflect a combination of runoff from ranching areas, and release of organic nitrogen from decomposition in Simpson Reservoir.

Median total ammonia concentrations were relatively low at all the sites and did not vary significantly between sites. All measurements were below the current Canadian Environmental Quality Guideline of 0.82 mg/L (CCME 2003) for the pH and temperature on the sampling day when the highest ammonia result was obtained (0.36 mg/L upstream from the Croatian Retirement Camp on April 14, 2003) (Figure 8). Unusually high ammonia was measured at three of the headwater sites on April 14, 2003. The source of the isolated high concentrations cannot be determined from the available data. Ammonia was high on that date both upstream and downstream of the Croatian Retirement Camp.

Concentrations of all forms of nitrogen were not significantly different upstream and downstream from the Croatian Retirement Camp. Furthermore, aside from nitrite+nitrate the concentration of these variables was either significantly lower in the tributary from Hacienda Estates than in Grand Valley Creek, or was not significantly different. Accordingly these results provide no evidence that either the Croatian Retirement Camp or Hacienda Estates had any appreciable impact on nitrogen levels during this sampling program.

3.4 COLIFORMS

Fecal coliforms are found in the intestinal tract of warm-blooded animals. They are a useful indication of contamination from sewage or manure. However, some fecal coliform tests will also detect bacteria that are not restricted to animal fecal contamination. *E. coli* is one species of fecal coliform bacteria, and is generally considered the preferred indicator for fecal contamination. Fecal coliforms and *E. coli* can affect the suitability of water for irrigation, contact recreation and drinking water. The tentative irrigation guideline for fecal coliforms is intended to protect consumers of irrigated produce that is typically eaten raw.

Both fecal coliforms and *E. coli* increased downstream from Range Road 53, and counts were significantly higher at Wildcat Hills Road, Highway 1a and at the mouth of Grand Valley Creek than at all sites upstream from the Anchor X Ranch Road. Both variables were frequently over the irrigation and recreation guidelines at sites between the Wildcat Hills Road and the mouth of the creek, except for the site immediately downstream from Simpson Reservoir (Figure 9 and 10). These results suggest that most fecal material enters Grand Valley Creek between the Anchor X Road and the site near the mouth of the creek. Presumably coliform counts declined below the reservoir because die-off occurs in the reservoir. The highest coliform counts at these sites (peak *E. coli* counts range: 1500-2500) occurred in the spring between April 24 and June 17.

Fecal coliform and *E. coli* counts were not significantly different upstream and downstream from the Croatian Retirement Camp. Furthermore, both variables were lower in the tributary from Hacienda Estates than in Grand Valley Creek. Accordingly these results provide no evidence that

either the Croatian Retirement Camp or Hacienda Estates had any appreciable impact on coliform levels during this sampling program.

3.5 TOTAL SUSPENDED SOLIDS

Total suspended solids (TSS) is a measure of the total amount of suspended particles such as fine silt and clay, organic matter and small organisms in water. Suspended solids can carry nutrients and contaminants, are sometimes aesthetically undesirable and can kill aquatic life when they settle on a stream bottom. TSS is typically measured as nonfiltrable residue, or the mass of suspended sediment retained on a filter per unit volume of sample.

Median TSS concentrations were relatively low from the Croatian Retirement Camp to Range Road 53 (sites 2 to 5) in 2003, but increased appreciably downstream from Range Road 53 (Figure 11). TSS concentrations at all sites from the Anchor X Ranch Road to the mouth were significantly higher than at the two sites near the Croatian Retirement Camp and the tributary near Hacienda Estates. Although median TSS concentrations were relatively low, individual measurements were much higher. For example, peak values of 41.6 and 50 mg/L TSS were measured at the Wildcat Hills Road and near Griffin Valley Ranch during moderate flows (Figure 2), on April 24 and June 17, 2003, respectively.

Water quality guidelines for TSS are generally based on change in TSS relative to background concentration at individual sites. However, since there are no historical data for this creek, except for sampling at Highway 1a, it is difficult to evaluate TSS concentrations in 2003 relative to these guidelines. If the median concentration (7 mg/L) at the site furthest upstream, near the Griffin Valley Ranch, is used as the background concentration, the peak concentrations at the Wildcat Hills Road and Griffin Valley Ranch would exceed the CCME guidelines (short-term increase <25 mg/L for clear flow), as would the median concentration at the mouth, alone (increase <5 mg/L for long-term exposure). It should be noted that the site near Griffin Valley Ranch is upstream from most livestock production, yet median and maximum TSS levels were higher at this site compared to others downstream.

The highest median TSS levels occurred furthest downstream, at Highway 1a and at the mouth and may reflect agricultural activities downstream from Range Road 53 and bank erosion near Highway 1a. Since TSS concentrations are typically correlated with flow, and 2003 was relatively dry, TSS levels throughout this basin may be higher during normal and wetter years.

TSS levels were low upstream and downstream from the Croatian Retirement Camp. Furthermore, both variables were lower in the tributary from Hacienda Estates than in Grand Valley Creek. Accordingly these results provide no evidence that either the Croatian Retirement Camp or Hacienda Estates had any appreciable impact on TSS levels in Grand Valley Creek during this sampling program.

3.6 DISSOLVED OXYGEN

Adequate levels of dissolved oxygen (DO) are essential for the maintenance of aquatic life. Excessive growth of aquatic plants and decomposition of organic matter can cause low levels of dissolved oxygen. High temperatures can also reduce the solubility of oxygen in water.

Most DO measurements in the Grand Valley Creek basin were well above both the Alberta and CCME guidelines of 5.0 and 6.5 mg/L for cold water fish species (Figure 12). The sole exceptions were individual measurements of 6.44 and 5.56 mg/L in Grand Valley Creek at Range Road 53 and the Anchor X Ranch Road, both on July 17, 2003. Accordingly this sampling provides no evidence of DO levels that would be insufficient for sport fish in Grand Valley Creek. Dissolved oxygen was higher in Grand Valley Creek at Wildcat Hills Road than at all the other sites. Since these measurements were all made in the afternoon between 13:30 and 14:50, these higher measurements probably reflect oxygen release by aquatic plants such as periphyton during the day. Lower levels of DO may occur at some of these sites at night due to nocturnal respiration by aquatic plants.

3.7 WATER TEMPERATURE

Water temperature strongly influences the chemical and biological processes in a stream. Temperature changes can alter algal, benthic, and fish communities, decrease diversity, and increase biological productivity. Higher temperatures also decrease the solubility of oxygen in water, thereby decreasing the availability of dissolved oxygen to fish.

Water temperatures at the Grand Valley Creek sampling sites upstream from the Simpson Reservoir were generally low (Figure 13), although air temperatures ranged up to 29° C (Figure 14). All measurements but one (22.01° C at the Anchor X Ranch Road, 17 July 2003) were below 22° C. All the widely accepted temperature guidelines in AENV (1999) are expressed as narratives or relative change in temperature, rather than absolute numerical limits. However, Taylor and Barton (1992) have proposed acute water temperature criteria no lower than 22° C for all the common sport fish in Alberta. Accordingly, sport fish should survive in Grand Valley Creek upstream from Simpson Reservoir. Water temperatures were much higher at the mouth of Grand Valley Creek (up to 25.61° C, Figure 13), and would not be suitable for some less tolerant fish species.

3.8 pH

The effective concentration, or activity, of hydrogen ions in water is represented by pH, which indicates the balance between acids and bases in water. The pH of water may influence the species composition of an aquatic environment, and can affect the availability of nutrients and relative toxicity of many trace elements.

All pH measurements were well within the CCME water quality guideline of 6.5 to 9.0 (AENV 1999). However, a large increase in pH occurred downstream from the Anchor X Ranch Road (Figure 15), and pH was significantly higher at all sites downstream from the Anchor X Ranch Road, than upstream. The reason for this increase cannot be determined with the available

results. One possibility is that pH may be increased in this reach due to uptake of carbon dioxide by aquatic plants (Wetzel 1983). Phosphorus levels increased greatly downstream from Range Road 53, and are probably high enough to increase the growth of periphyton. Effects of increased algal production on pH may not occur until the Wildcat Hills Road.

3.9 CONDUCTIVITY

Conductivity, or specific conductance, is a measure of the ability of water to conduct an electrical current. Because the presence of charged ionic species in solution makes the solution conductive, this variable provides an indication of total dissolved solids or ionic concentration of the water.

Conductivity was moderately high throughout the Grand Valley Creek basin, and increased greatly from the site near the Griffin Valley Ranch to the site upstream from the Croatian Retirement Camp (Figure 16). Conductivity was significantly higher in the tributary near Hacienda Estates than in Grand Valley Creek. Currently, no surface water quality guidelines for conductivity exist.

4.0 CONCLUSIONS

1. This sampling program provided no evidence of adverse water quality impacts on Grand Valley Creek from either the Croatian Retirement Camp or residential properties at Hacienda Estates in 2003.
2. Coliform counts, TP, and TDP concentrations in Grand Valley Creek increased above the available water quality guidelines downstream of Range Road 53. This suggests that ranching activities downstream from Range Road 53 may be affecting water quality in Grand Valley Creek.

5.0 RECOMMENDATIONS

1. There was little precipitation during this sampling program, and creek flows were negligible after July 18, 2003. There could be more movement of nutrients and coliforms to Grand Valley Creek from septic fields and ranching areas during wetter years, especially during spring runoff. Another year of sampling during a year with higher precipitation would better define the natural range of variation in water quality and flow. Future sampling should include the variable periphytic chlorophyll *a*, to improve our understanding of changes in algal productivity along the creek.

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Figure 1. Sampling locations on Grand Valley Creek in 2003

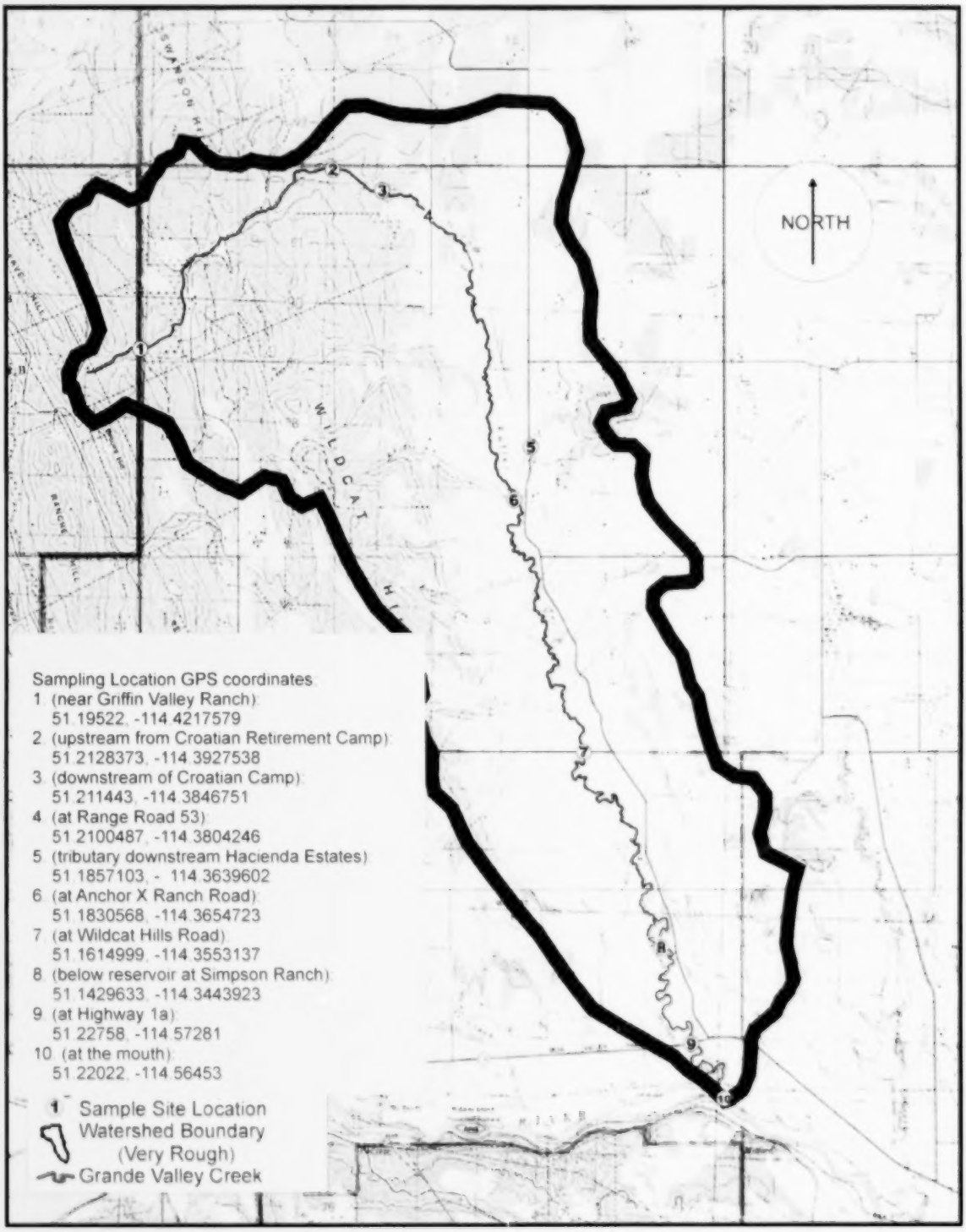

Figure 1. Sampling locations on Grand Valley Creek in 2003

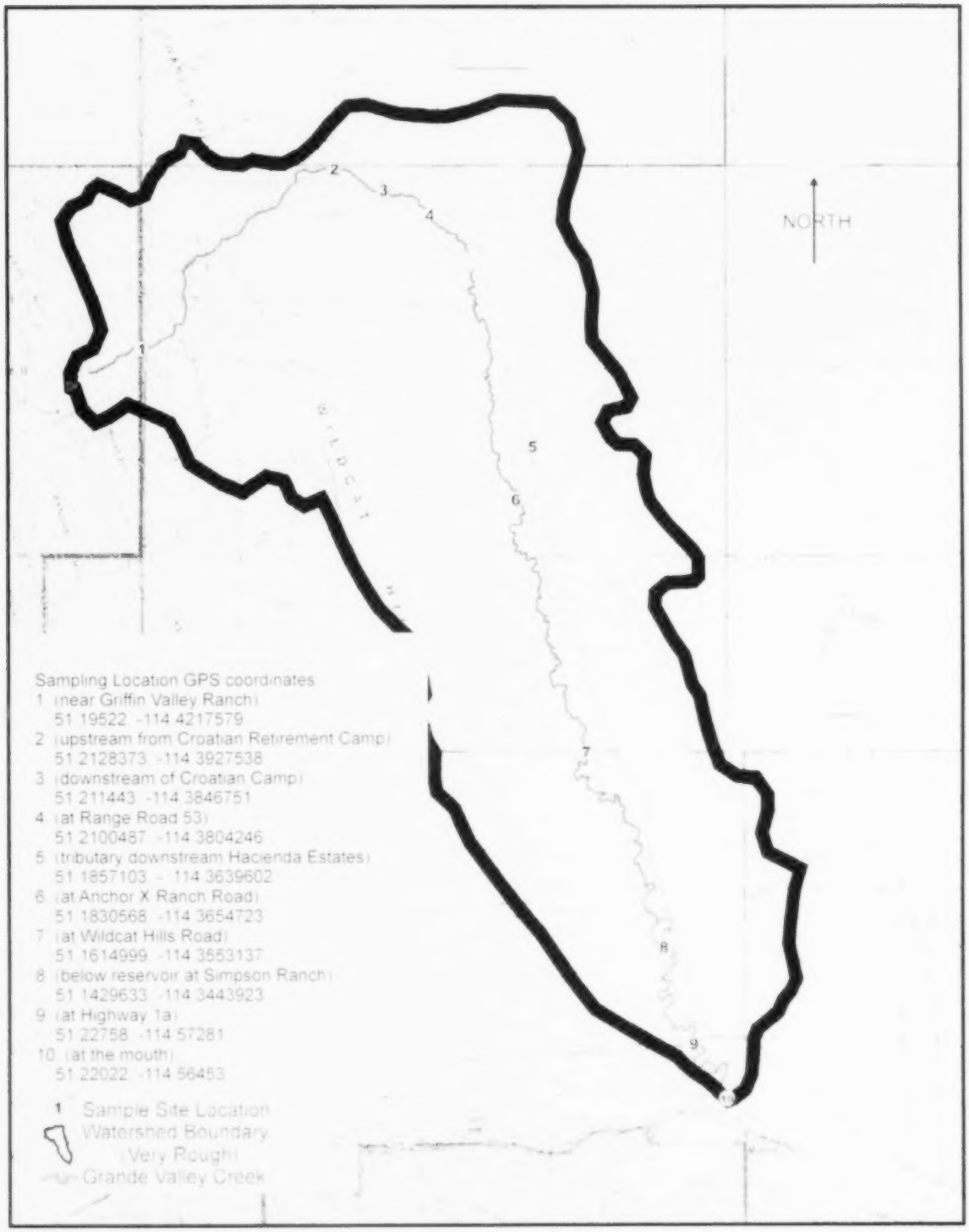

Figure 2. Discharge in Grand Valley Creek near Cochrane (05BE905), April 14-July 18, 2003

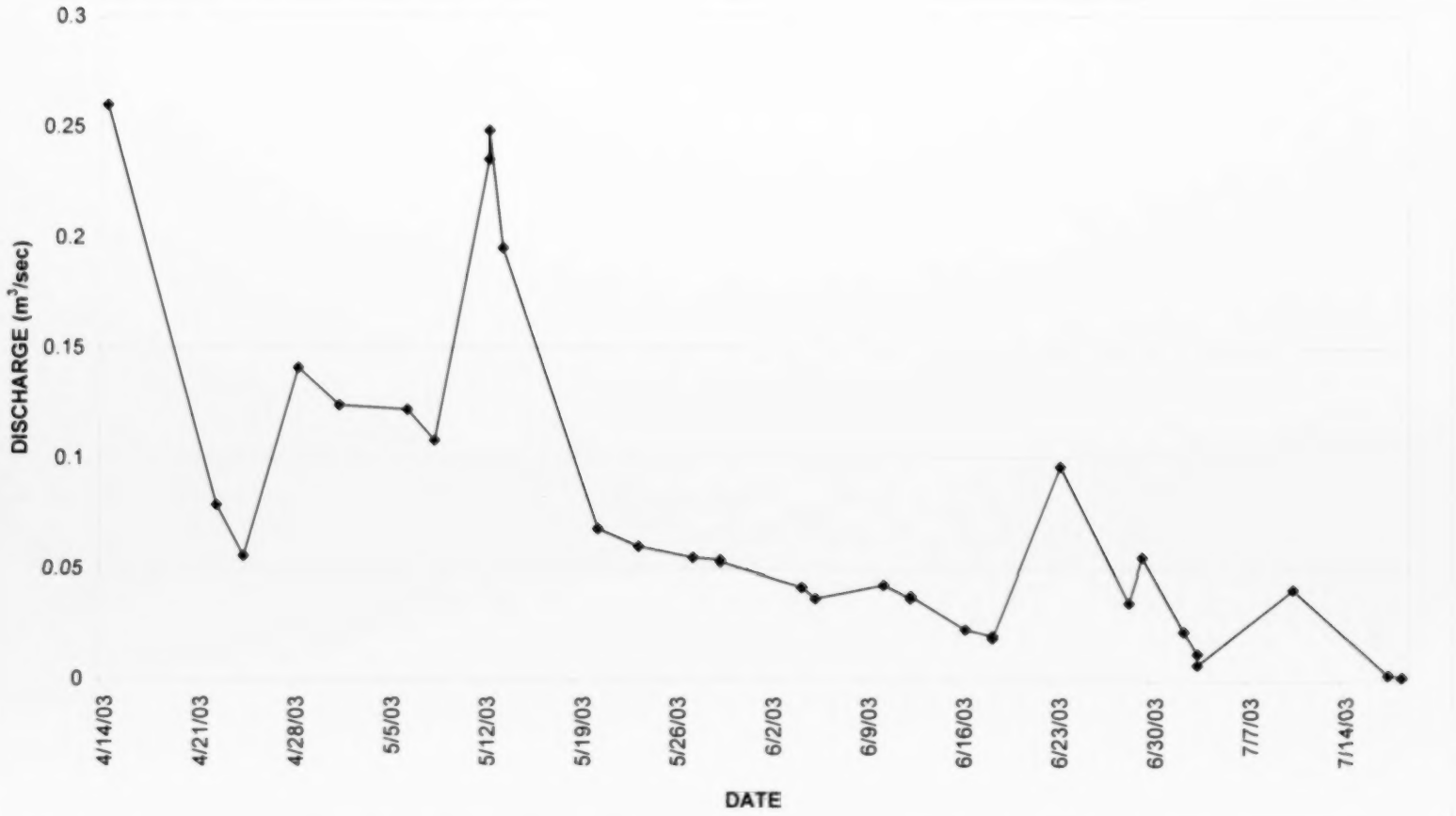

Figure 3. Total phosphorus at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

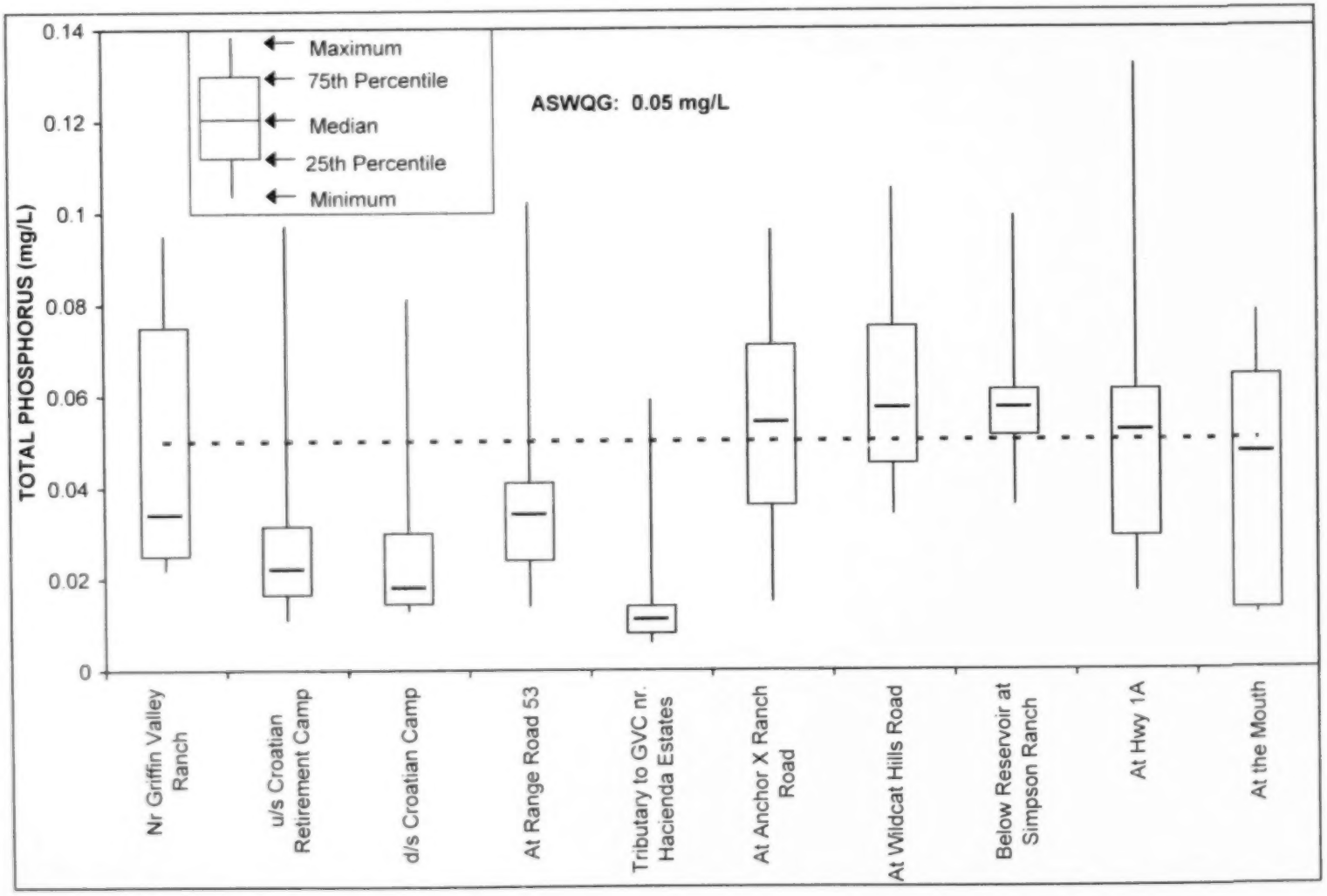

Figure 4. Total dissolved phosphorus at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

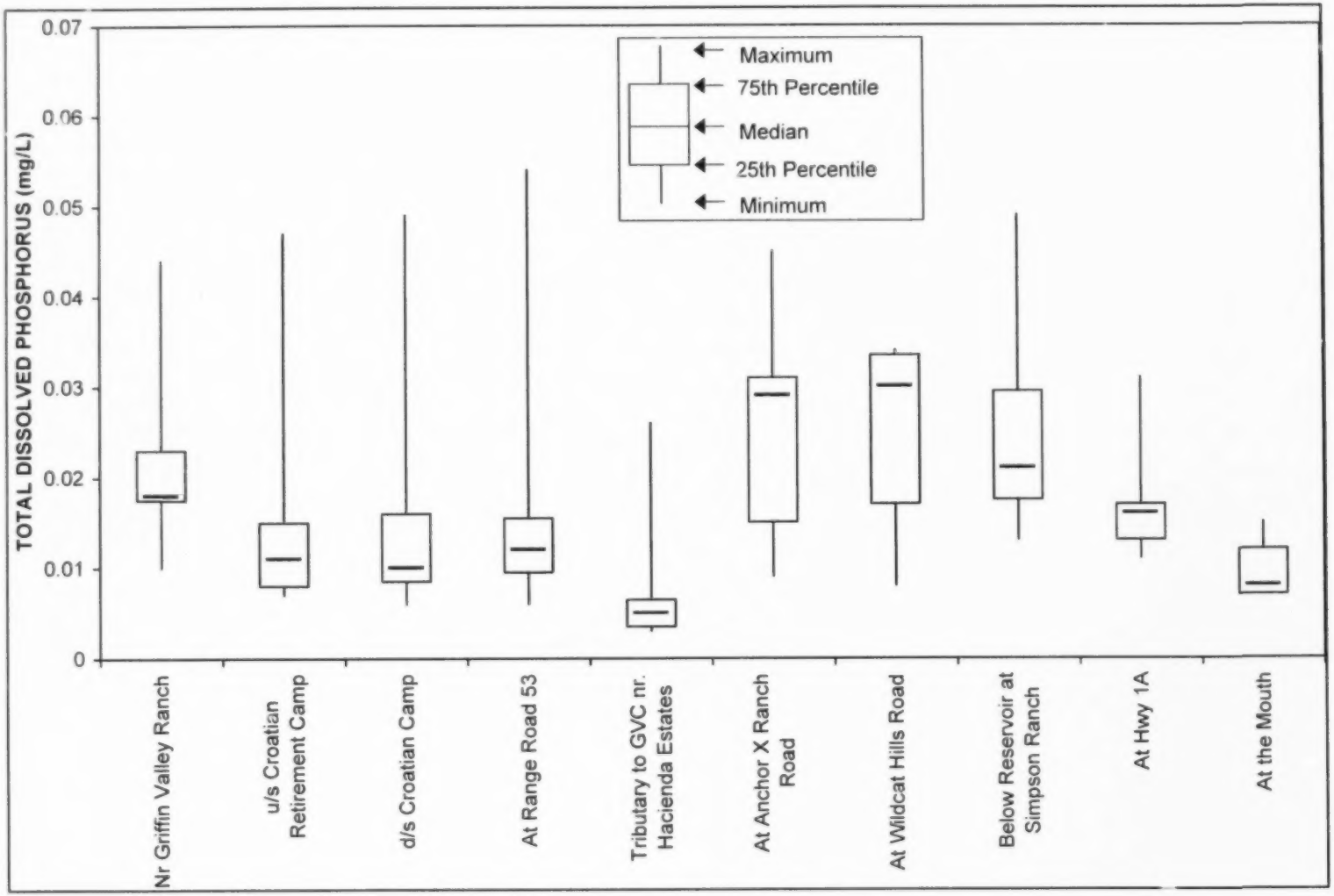

Figure 5. Total nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

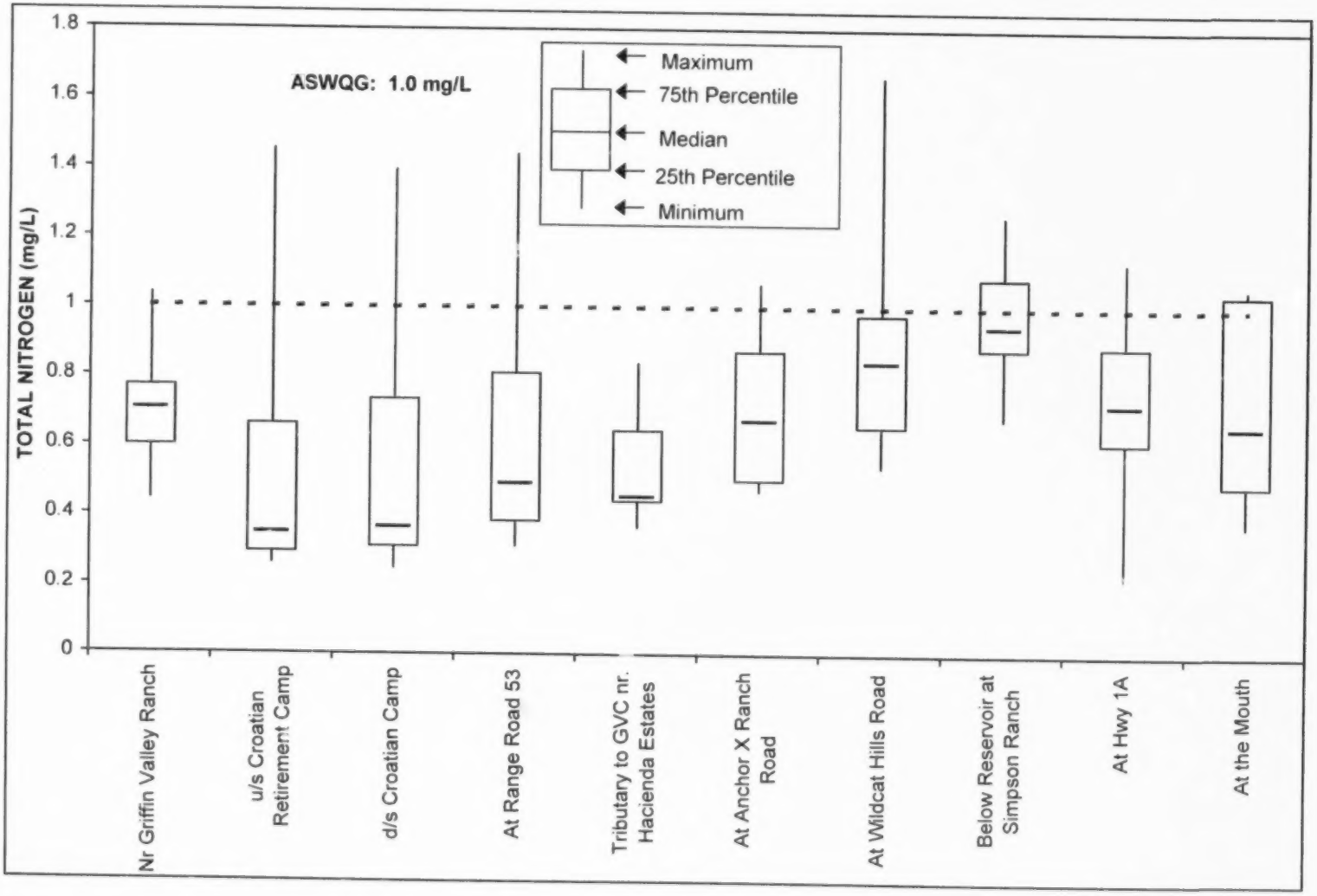

Figure 6. Nitrite+nitrate nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

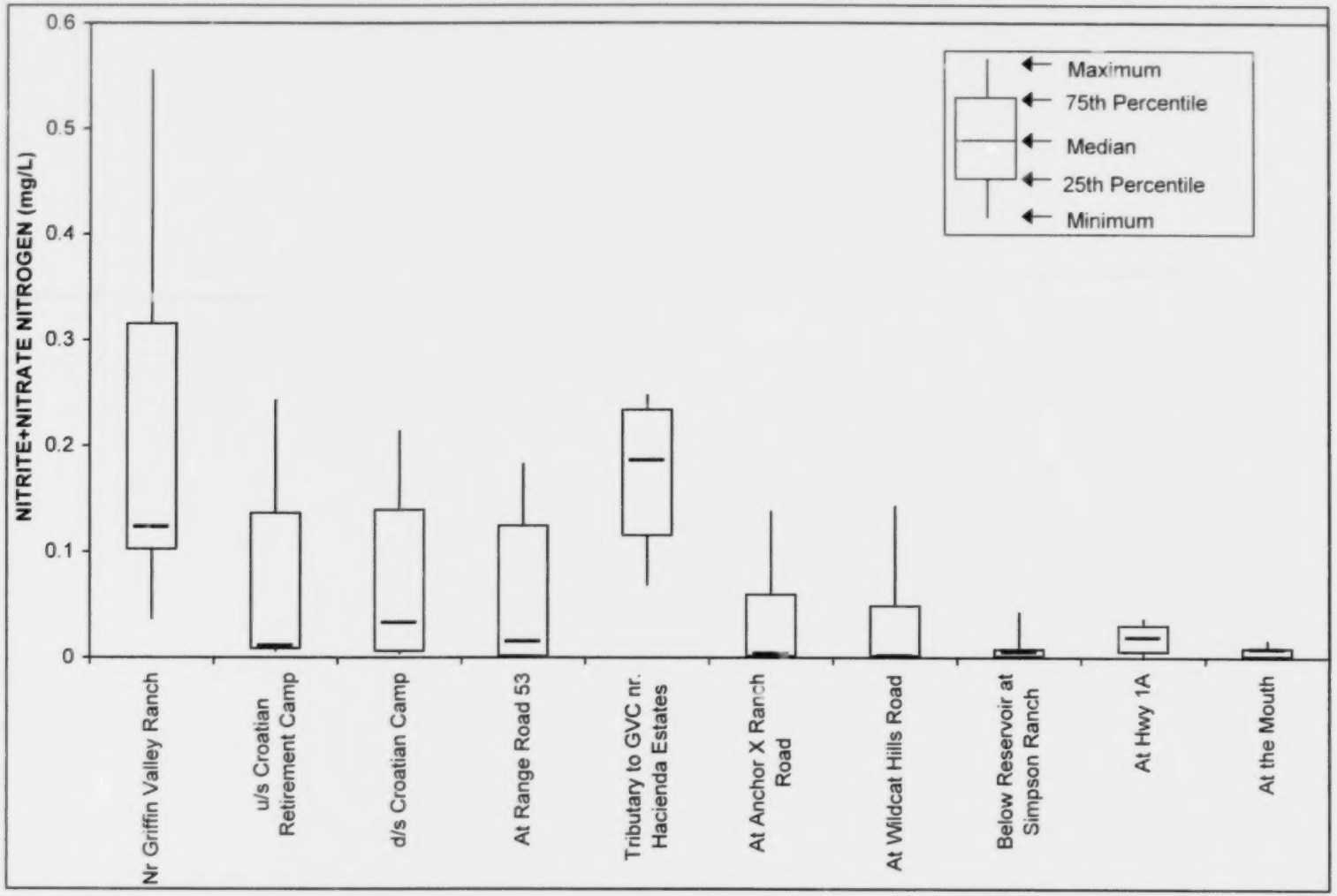

Figure 7. Total kjeldahl nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

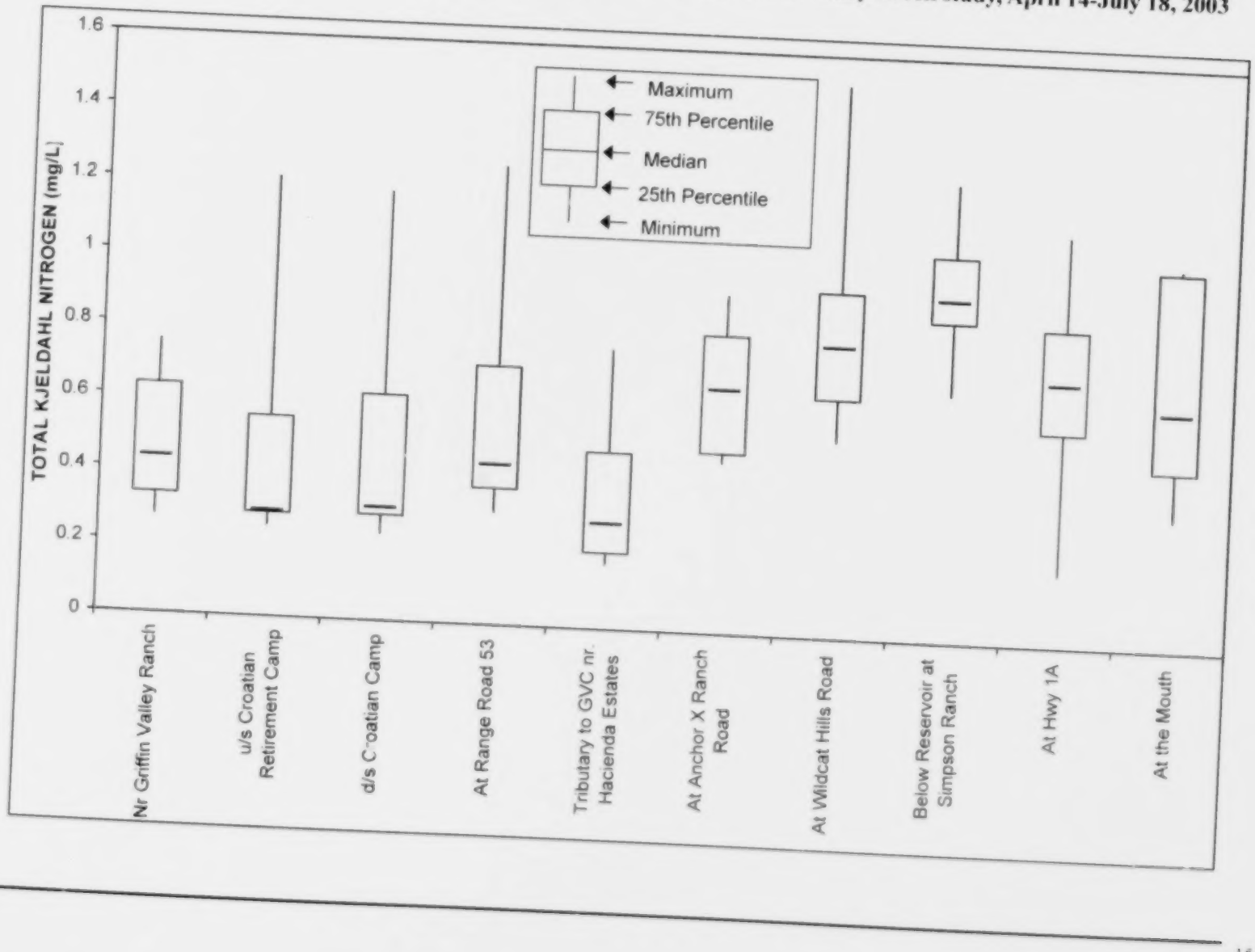

Figure 8. Total ammonia nitrogen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

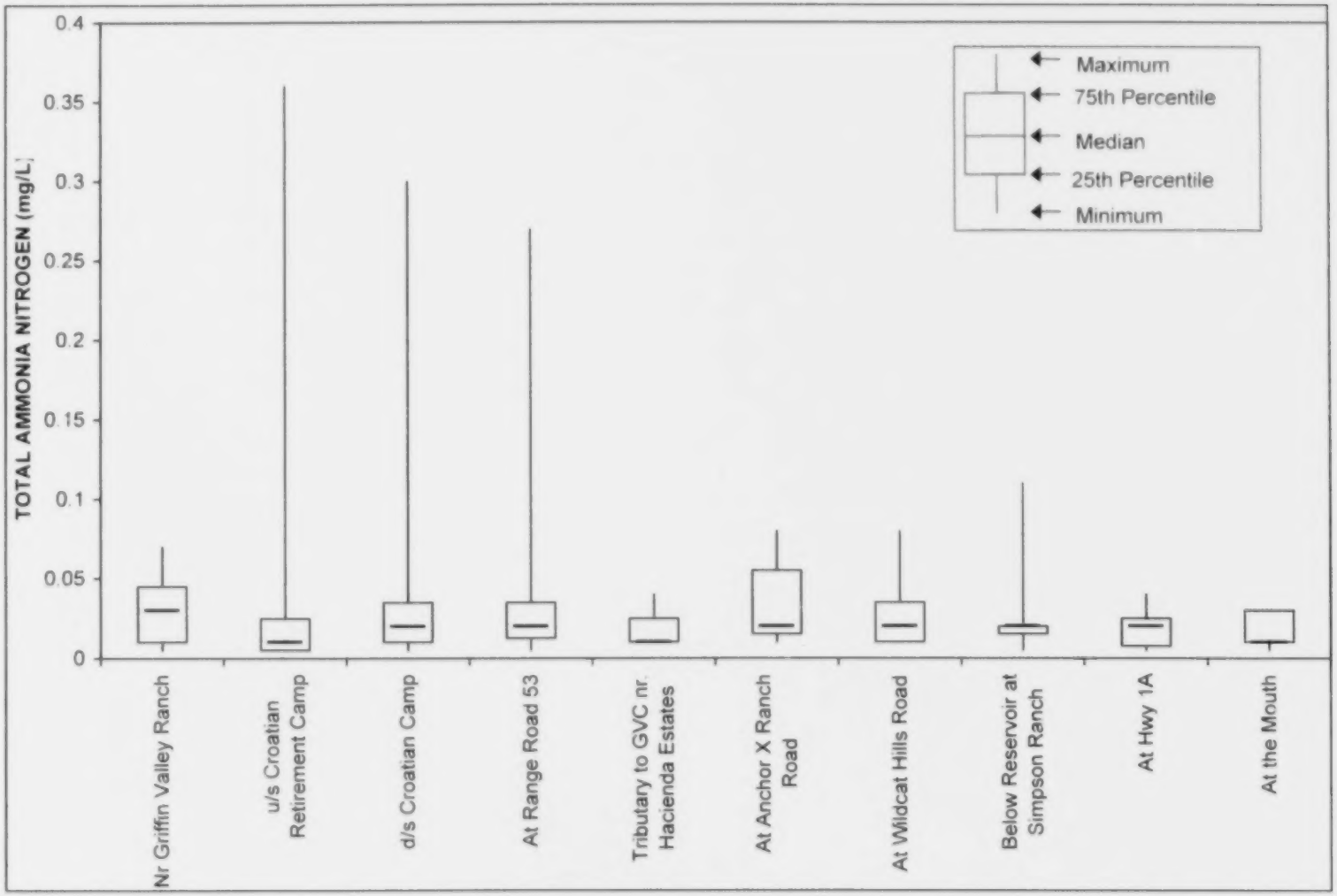

Figure 9. Fecal coliform counts at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

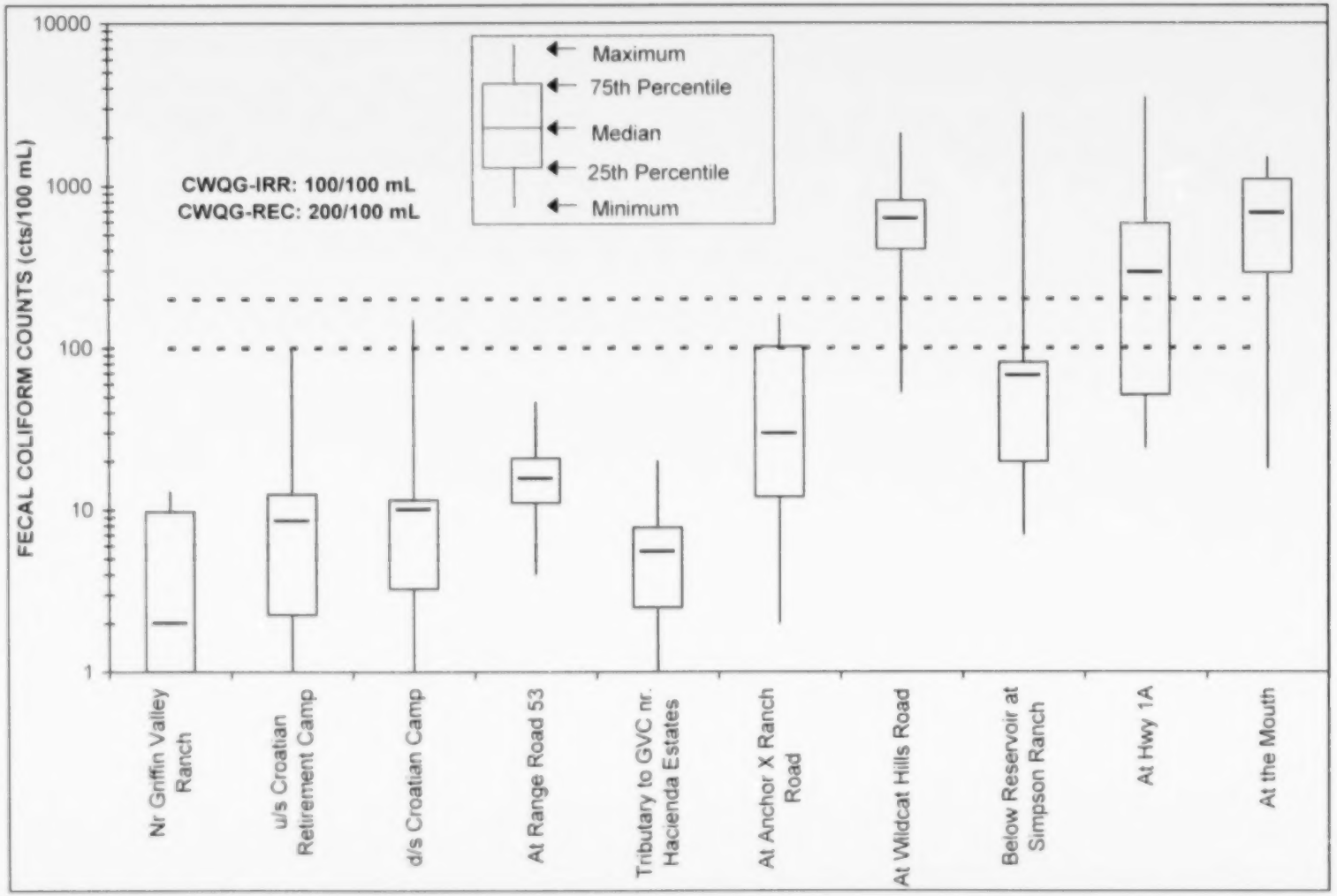

Figure 10. ***Escherichia coli*** **counts at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003**

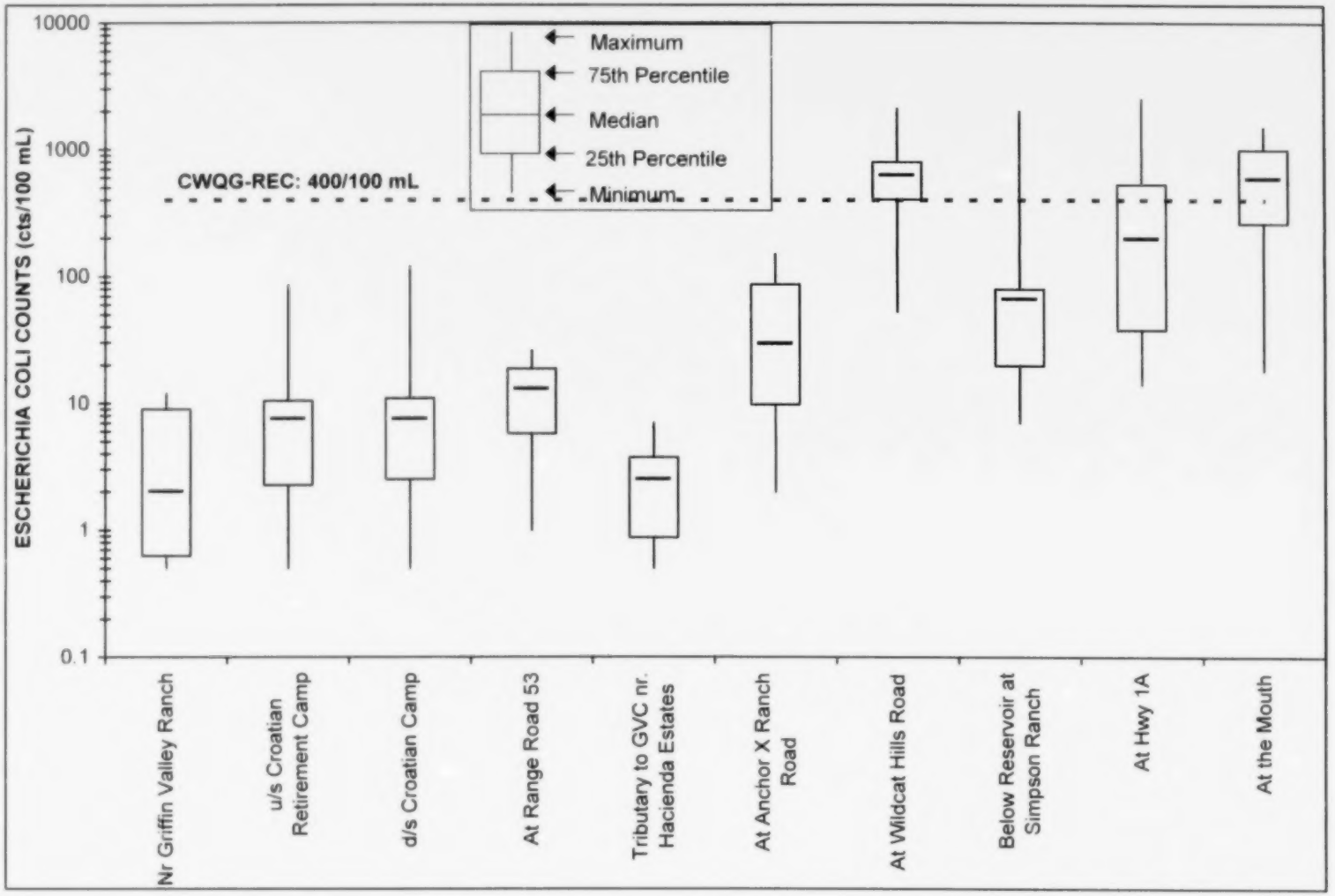

Figure 11. Non-filterable residue at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

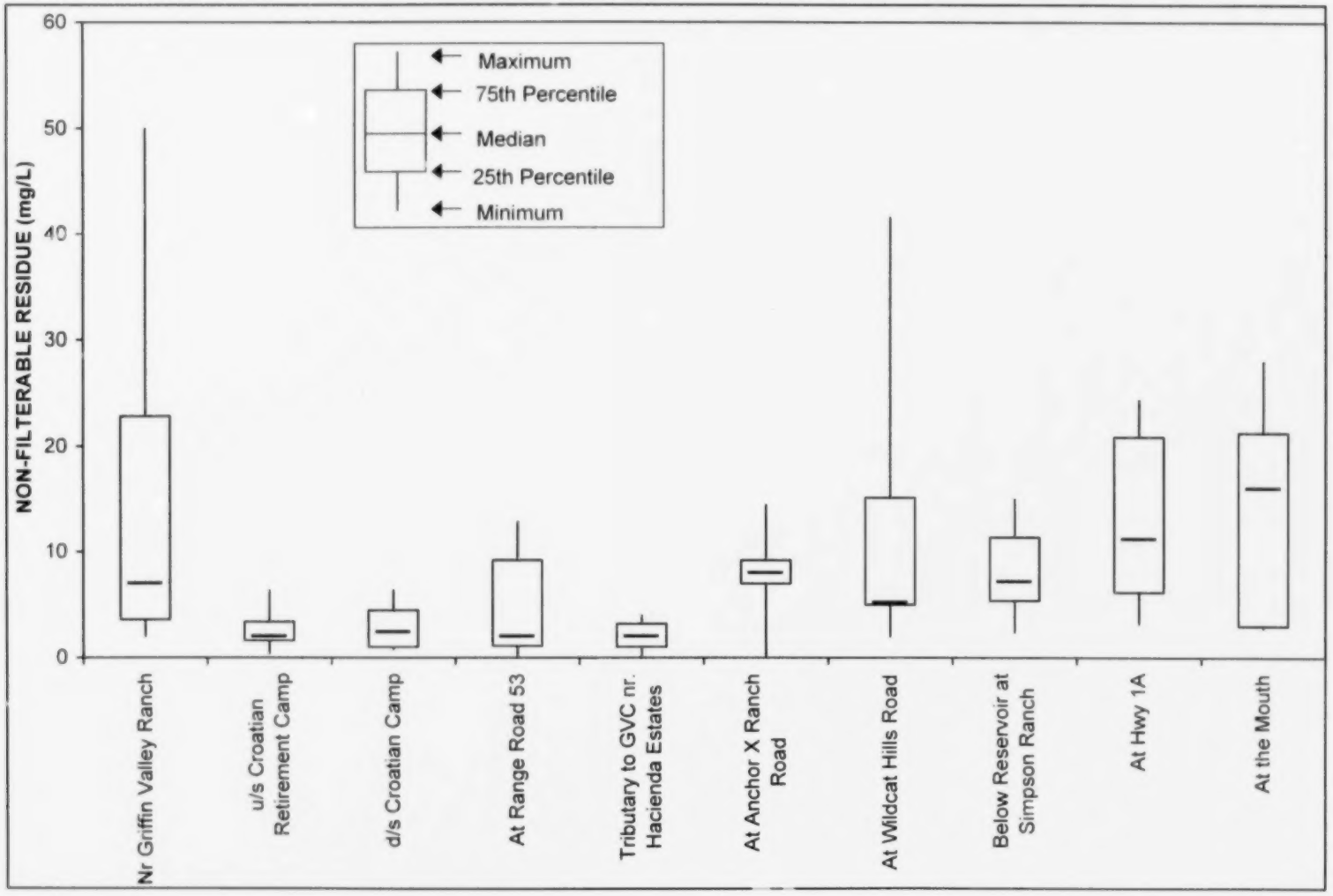

Figure 12. Dissolved oxygen at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

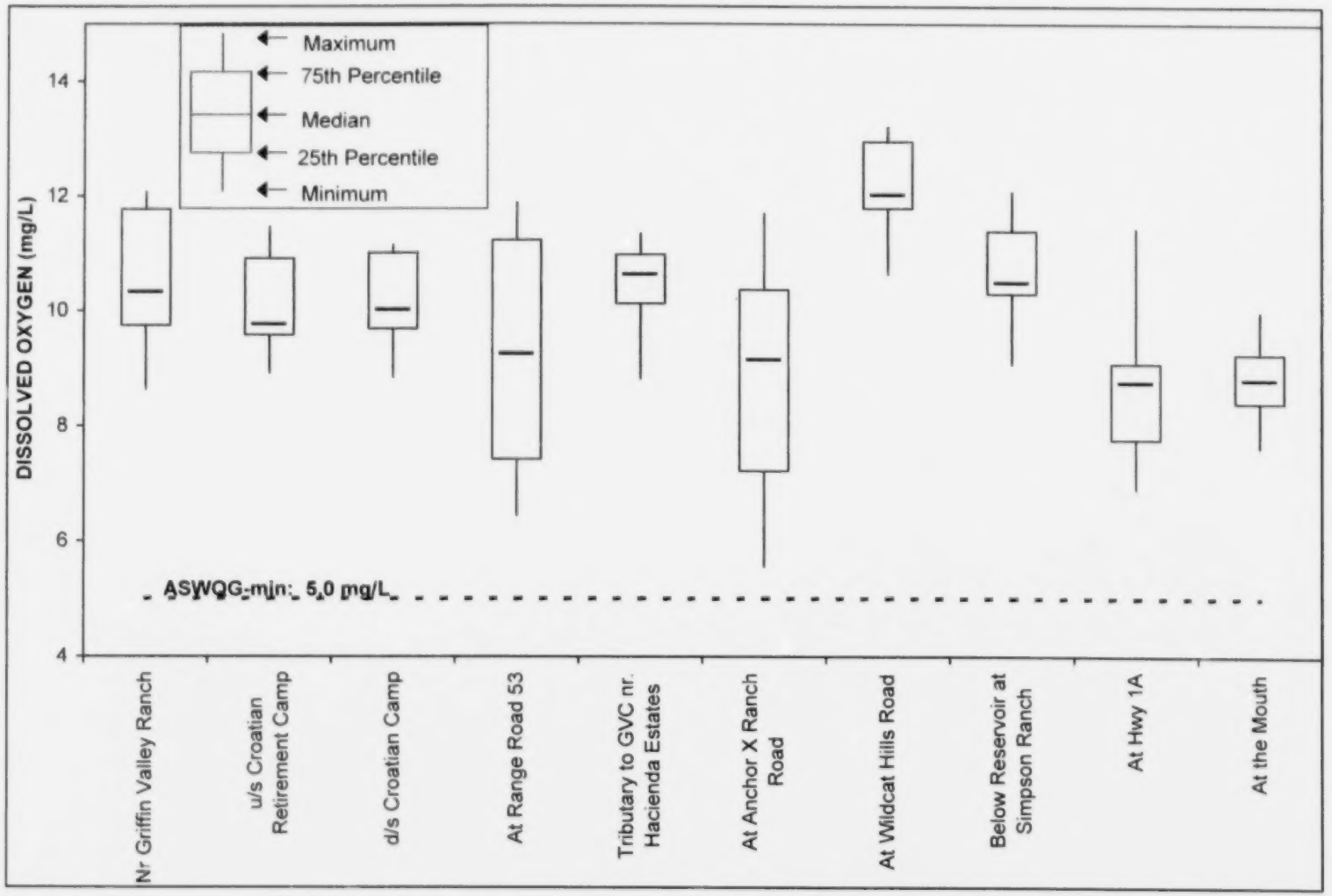

Figure 13. Water temperature at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

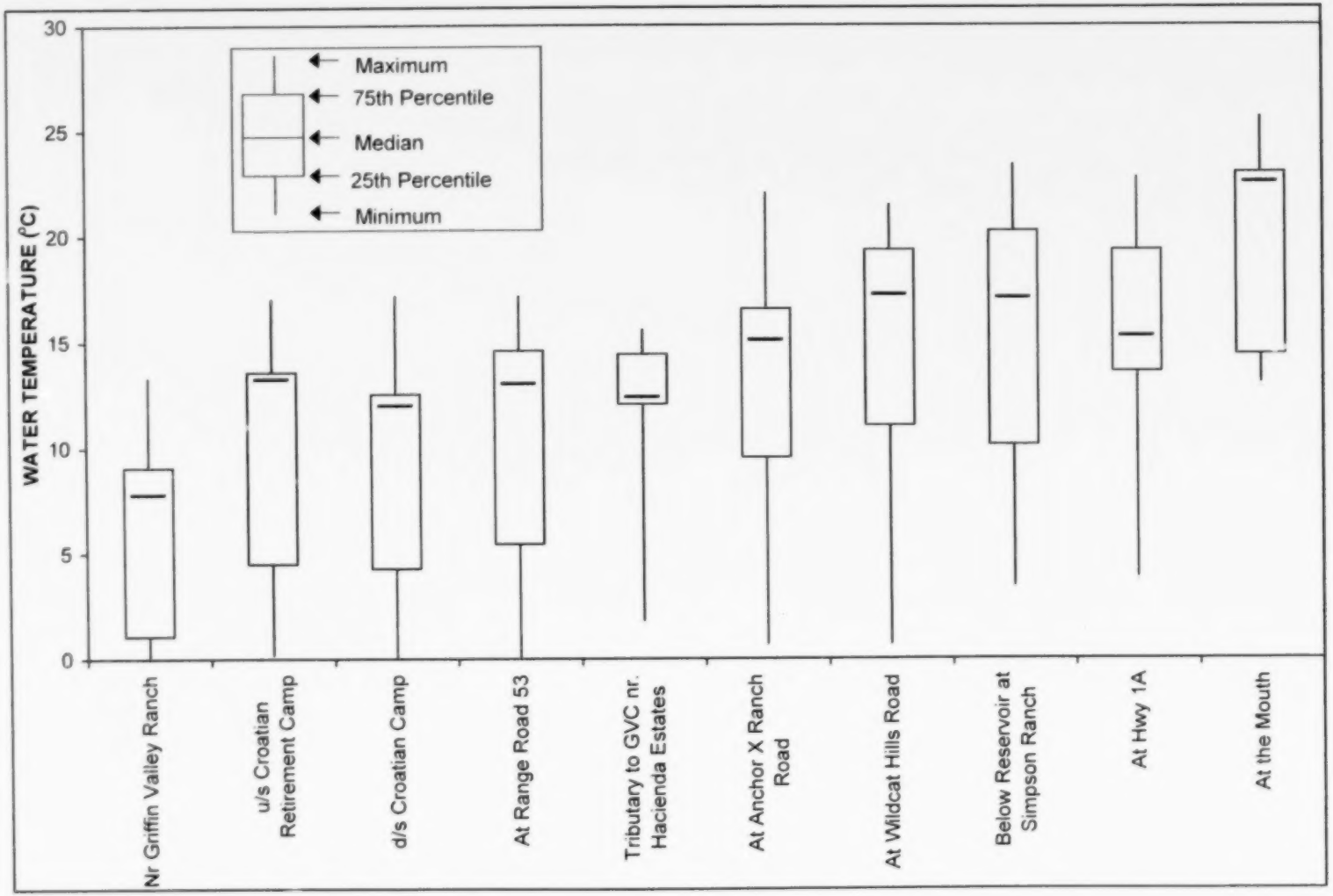

Figure 14. Air temperature at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

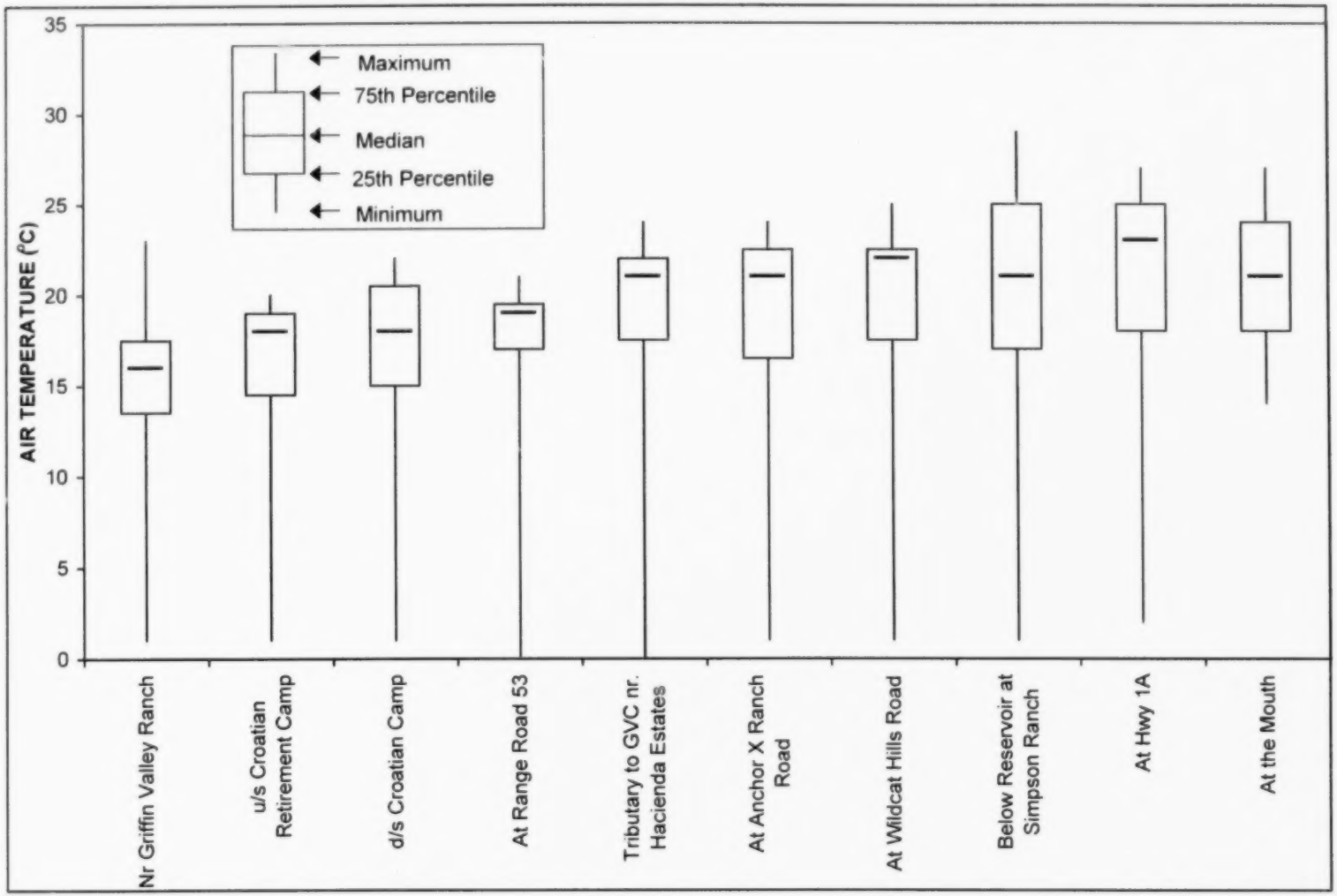

Figure 15. pH at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003

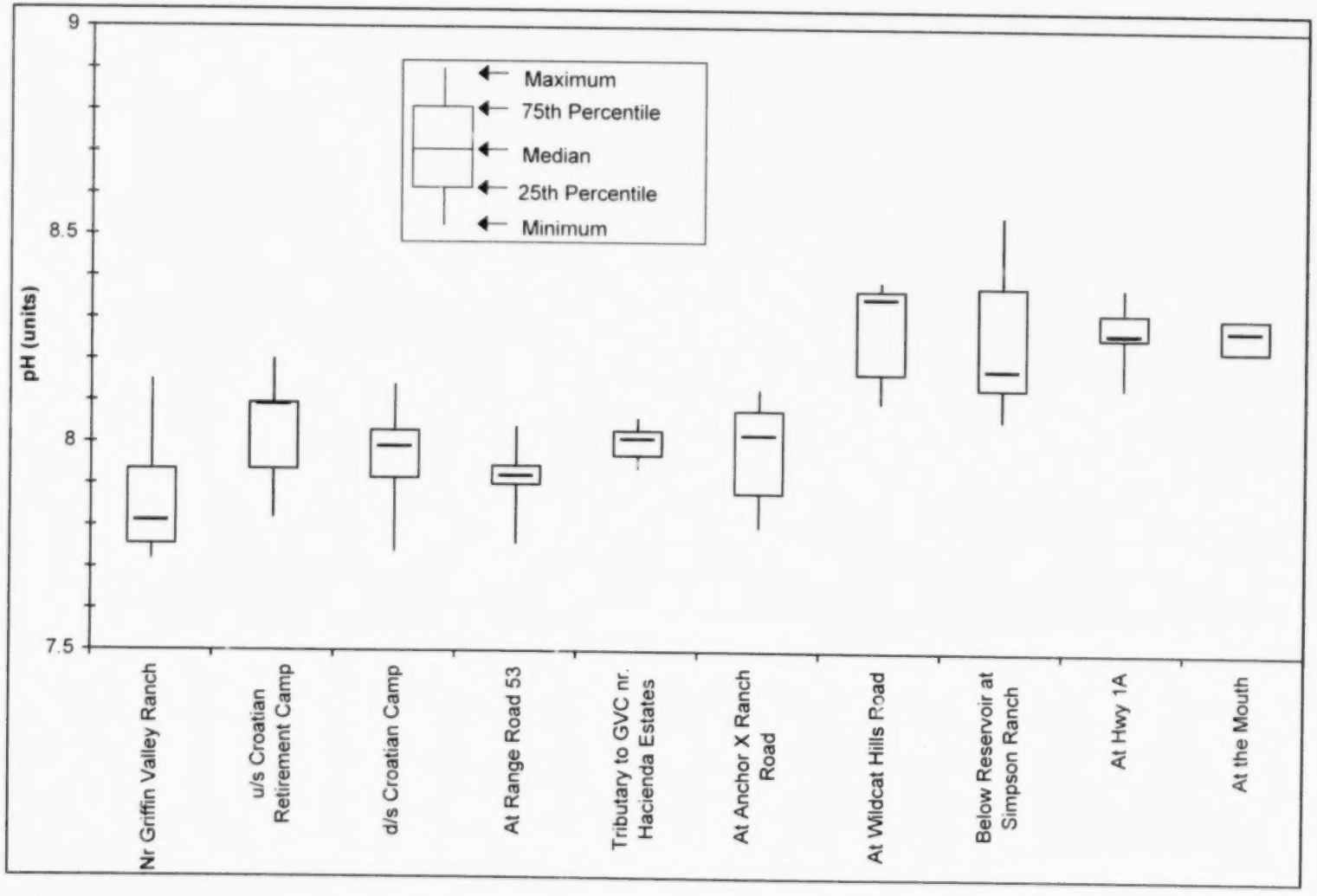

Figure 16. Specific conductance at all sites sampled during the Grand Valley Creek study, April 14-July 18, 2003